Statistical Models for Stockpile and Complex System Health Assessment

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The LANL Statistical Sciences Group (CCS-6) has an ongoing applied research effort to develop methods and software tools to help assess the health of conventional and nuclear stockpiles. Given the complex technical and data issues associated with understanding stockpiles, CCS-6 works within LANL to apply the best data analysis methods to support decision making about the enduring U.S. nuclear stockpile. Likewise, CCS-6 collaborates with the Department of Defense (DoD) and other agencies on problems that improve the understanding of weapon stockpile assessment and complex system reliability.

We have developed statistical methodology for a number of problems arising in reliability assessment. This includes appropriately handling multilevel data using reliability block diagram and fault tree representations, using age and usage covariates to improve reliability estimates, combining expert knowledge with available data, and faithfully dealing with the less-than-ideal data. We have also developed and applied methodology to associate uncertainties with reliability assessments. Finally, much of the implementation has been done using GROMIT and YADAS, software tools we have developed to address the system modeling and statistical challenges often presented by weapons data [1,2] (see also yadas.lanl.gov).

Our recent successes in supporting the weapons program have included the following effort:

- Combine diverse data types (e.g., pass/fail, accelerated, degradation, lifetime and specification data, and expert judgment) at multiple levels (e.g., system, subsystem, component) to evaluate system reliability [3,4,5,6].

- Model reliability as a function of multiple lifecycle covariates [7].

- Take indirect measurements to make inference about characteristics based on direct measurements that were not taken [8].

- Estimate the proportion of a population with an attribute from data that were purposely biased to contain units with that attribute [9].

Fig. 1. CCS-6 is collaborating with Naval Surface Warfare Centers to assess the reliability of the RAM and AMRAAM missile systems.

- Analyze degradation data with a proposed model that implies a Weibull lifetime distribution and determine how reliability can then be assessed [10].

- Support assessments of reliability margins with statistical models and analyses [11].

- Understand how to collect degradation data over time for applications like shelf-life programs [12].

- Track and trend surveillance streams from LANL stockpile weapons to help assess stockpile health [13,14,15,16,17,18].

- Enhance and expand capabilities for YADAS [14,19].

Past and current DoD collaborators include AMRDEC Huntsville, MCPD Fallbrook, NSWC Corona, and NSWC Yorktown.

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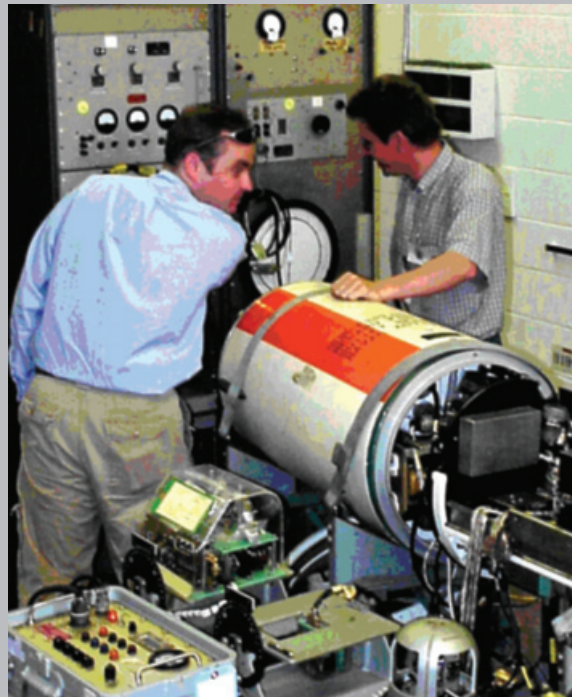
Fig. 2. Andrew Wiedlea and Nick Hengartner examine a test set used to collect data on the health and functionality of components from weapons like the MK 67 submarine-launched mine in the picture.
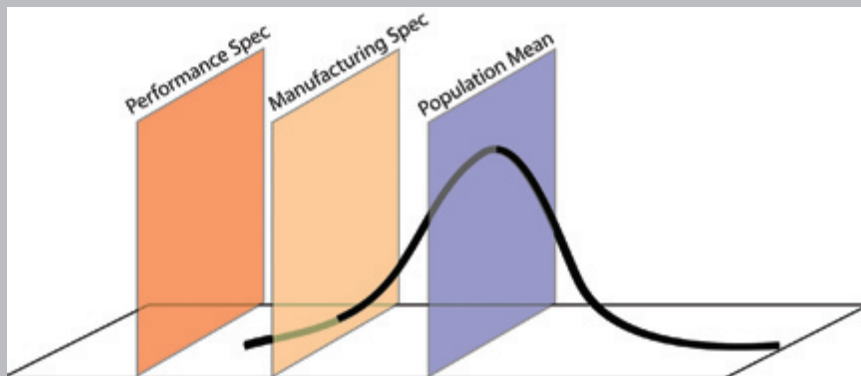

Fig. 3. CCS-6 is working with the LANL Core and Enhanced Surveillance programs to track and trend weapon surveillance data streams. The goal is to assess key weapon characteristics against known specifications and estimate the distribution of these characteristics in the stockpile now and in the future.

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